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ON THE OSTEOLOGY OF THE TUBINARES.

R. W. SHUFELDT.

I. HISTORICAL.

Few of the groups of Birds have a more interesting literature than this Suborder.

As early as 1827 M. L'Herminier placed the Tubinares together in a family of birds (28th) and classified them upon the characters of their sterna, assigning them to three sections; (1) the smaller Petrels in which the xiphoidal end of the sternum was entire or nearly so; (2) the Albatrosses, where it presented a shallow notch upon either side of the carina; (3) those Petrels in which two well-marked notches occurred on either side of the sternal keel.¹

M. M. Hombron and Jacquinot in the year 1844, added something to our knowledge of the Tubinares,² and they classified the group upon the morphology of their palates, tongues, and beaks. In one genus they placed the three genera *Diomedea*, *Puffinus* and *Prion*, in another, the genus *Prion*, and finally, in their third genus,—*Procellaria*. By them *Pelecanoides* was removed from the *Procellariidæ*, and placed in the *Alcæ* near *Alle*, which they considered its nearest relative (*A. nigricans*). Five years later Gray and Mitchell (1849) divide the *Procellariidæ* into the *Diomedeinæ* and the *Procellariinæ*, and the last named into 5 genera (*Prion*, *Pelecanoides*, *Thalassidroma*, *Procellaria*, and *Puffinus*), the group constituting the fourth family of their *Anseres*.³ In his *Conspectus*, Bonaparte divides the *Procellariidæ* into the *Diomedeinæ*, *Procellariinæ*, and the *Halodrominæ*; the second

¹ Recherches sur l'appareil sternal des Oiseaux, pp. 79–81. v. iv. Paris, 1827.

² Remarques sur quelques points de l'anatomie et de la physiologie des *Procellarides*, et essai d'une nouvelle classification des ces oiseaux, *Compt. Rend. de l'Acad. Sci.* xviii, 1844, pp. 353–358.

³ The Genera of Birds, iii, pp. 646–650.

subfamily being subdivided into five lesser groups.¹ But a few years later (1864-66) this constitution was followed by the far more accurate work of Coues, though that distinguished ornithologist complains of "having suffered not a little from imprudence in believing Bonaparte," whom to some extent he followed, but upon the whole has given us a more natural classification of the Tubinares.²

Both Bonaparte and Coues based their classification upon the topographical anatomy of the birds of the suborder we are now considering, but this was not the case with Eyton nor with Milne-Edwards; nor with Huxley who followed them.³ All these distinguished authors dealt more or less thoroughly with the osteology of many of the Tubinares, as well as with such characters as procellarine species presented externally. Eyton figured the bones of the skeleton of several varieties of Albatrosses, and forms related to them. Milne-Edwards pointed out the relations existing among Petrels, Gulls, and the Steganopodes; showing that the first two were more or less closely akin, and both more remotely related to the last-named group of Birds. Huxley in one of his groups of Schizognathous forms, the Cecomorphæ, in his celebrated paper, placed the Divers, the Auks, the Gulls, and the Petrels in a group by themselves, and of the Procellariidæ says that they "are aberrant forms, inclining towards the Cormorants and Pelicans among the Desmognathæ" (*loc. cit.*, p. 458).

Next of importance we find Professor Reinhardt in 1873, touching upon certain anatomical characters of Petrels, Albatrosses, and Puffins, and presenting his classification of the Group, and to his paper the reader is referred, inasmuch as his results are

¹ *Conspectus generum avium*, 1857, tom ii, pp. 184-206.

² Coues, E. Critical Review of the Family Procellariidæ. *Proc. Acad. Nat. Sci. Phila.* pt. 1, (pp. 72-91); pt. 2, (pp. 116-144); pt. 3, (pp. 25-33); pts. 4 and 5 (pp. 134-197). Parts 1 and 2 appeared in 1864, and the remaining parts in 1866.

³ Eyton, T. C. *Osteologia Avium*, Lond. 1867, pp. 221-225.

MILNE-EDWARDS, M. AL. *Recherches anatomiques et paleontologiques pour servir a l'histoire des oiseaux fossils de la France*. Paris, 1867-68.

Huxley, Thos. H. On the Classification of Birds, etc. *P. Z. S.* 1867, pp. 415-472.

too extensive to present in this connection.¹ That same year likewise saw Garrod's studies of the Petrels appear, and finding them 'holorhinal,' he parted them from the 'schizorhinal' Gulls and related forms exhibiting a similar character.²

Other papers and works of minor taxonomic importance continued to be put forth, when in 1882 appeared the very extensive and meritorious work of Forbes dealing with the entire anatomy of many forms of the Tubinares, and a thorough study of their probable affinities.³

Forbes divided the Tubinares into two families, the Oceanitidæ and the Procellariidæ, which last was subdivided into the two subfamilies — Diomedeinæ and the Procellariinæ. Osteology of the Petrels and their allies filled a prominent place in this able production, and I shall frequently have occasion in the present brief article to refer to it, especially in instances where its author had skeletons of species which the writer has not been able to secure.

Another classification is seen in that of Dr. Stejneger which was published in the Standard Natural History (Boston) in 1885. The following selected from his scheme will show where he places the Tubinares: —

Subclass IV. Super-Order III. Order VI. Superfam. V.
Eurhipiduræ { Euornithes { Cecomorphæ { Procellaroidæ.

In the Procellaroidæ are arrayed the three families Diomedidæ, Procellariidæ, and the Pelecanoididæ. This writer places in his scheme the Tubinares widely removed from the Steganopodes, which I believe to be a mistake, and a non-appreciation of the morphological characters of the latter group of Birds.

In his great work upon the anatomy and taxonomy of birds, Fürbringer makes the Procellariiformes an 'Intermediate Suborder'

¹ Reinhardt, J. Om Vingens anatomiske Bygning hos Stormfugle-Familien. Viden. Medd. Naturh. For. Kjöbenhavn, 1873, pp. 123-138.

² Garrod, A. H. Collected Papers, p. 128.

³ Forbes, W. A. Report on the Anatomy of the Petrels (*Tubinares*) Collected during the Voyage of H. M. S. Challenger. (Zool. Chall. Exp. vol. iv, pt. xi, pp. 1-64. Pls. i-vii (1882).)

[“This contribution will be found a most valuable addition to the literature on this remarkable order of pelagic birds.” John Murray.]

between his Orders Pelargonithes and Charadriornithes. He considers the Procellariiformes to contain the Procellariæ or Tubinares to which group he gives the name of 'Gens.' The Gens Procellariæ according to him contains but the single family — Procellariidæ. Above the Procellariiformes in the Order Pelargornithes we find the Gens Steganopodes.

In 1890 Mr. H. Seebohm in his "Classification of Birds,"—the "alternative scheme" makes an Order of the Tubinares, placing them in his subclass Ciconiiformes, between the Steganopodes and Impennes. Thus his *third* subclass of birds is arranged as follows:—

SUBCLASS.	ORDER.	SUBORDER.
3. Ciconiiformes.	Psittaci.	14. Psittaci.
	Raptores.	15. Striges.
		16. Accipitres.
	Pelecano-Herodiones	17. Serpentarii.
		18. Plataleæ.
		19. Herodiones.
	Tubinares.	20. Steganopodes.
	Impennes.	21. Tubinares.
		22. Impennes.

Professor Hans Gadow regards the Tubinares much in the same light as they are by Fürbringer, placing them as an Order Procellariiformes, (9), between the orders Sphenisciformes (8) and Ardeiformes (10), the first suborder of the latter being the Steganopodes.¹

The 'Procellariiformes' constitute Order XV of Dr. Sharpe's classification, and it is subdivided into a suborder — Tubinares, which latter is made to contain the three Families: (1) Diomeidæ, (2) Procellariidæ, and (3) Pelecanoidæ. Of this author's scheme, Order XIV contains the Sphenisciformes, and Order XVI, the Alciformes.² This authority likewise widely separates the Tubinares and the Steganopodes, the last being included in his Order XXIII or the Pelecaniformes (*loc. cit.* p. 76). In

¹ On the Classification of Birds, P. Z. S. 1892, pp. 229–256. [An able and useful paper.]

² Sharpe, R. Bowdler. A Review of the Recent Attempts to Classify Birds. Budapest 1891, pp. 71, 72.

1899 Dr. Sharpe changed this arrangement entirely as will be seen by the following scheme which represents I believe his latest opinions upon this subject.¹ He now places the Procellariiformes between the Sphenisciformes and the Alciformes.

ORDER (XII).	FAMILY.	SUBFAMILY.	GENERA.	No. of SPECIES.
Procellariiformes.	I Procellariidæ.	I Procellariinæ.	Procellaria.	2
			Halocyptena.	1
			Oceanodroma.	13
		II Oceanitinæ.	Oceanites.	2
			Garrodia.	1
			Pelagodroma.	1
			Pealea.	1
			Fregetta.	4
			Puffinus.	24
			Priofinus.	1
	II Puffinidæ.	I Puffininæ.	Thalassœca.	1
			Priocella.	1
			Majaqueres.	2
			Œstrelata.	31
			Pagodroma.	1
			Bulweria.	2
			Ossifraga.	1
		II Fulmarinæ.	Fulmarus.	4
			Daption.	1
			Halobæna.	1
			Prion.	4
		III Pelecanoididæ.	Pelecanoides.	3
		IV Diomedeidæ.	Diomedea.	10
			Thalassogeron.	6
			Phœbetria.	1

This scheme does not enumerate the fossil or subfossil forms given by Dr. Sharpe in the *Hand-List*, of which not a few have been discovered and described. There are about 120 species of Tubinares known to science, and this scheme is very useful in exhibiting at a glance their distribution into genera.

¹ Hand-List of Birds. Vol. I, pp. 120-129. Lond. 1899.

Cope essentially agrees with Stejneger as given above, with the exception that the Superfamilies of the latter are equal to the families of the former. Thus Cope makes the Cecomorphæ contain the families Colymbidæ, Heliornithidæ, Alcidæ, Laridæ, and Procellariidæ.¹

The writer of the present memoir added his own studies to the literature of this subject in a paper published in 1889, which appeared in the Proceedings of the United States National Museum, it being, in its aim, more descriptive of material than in the collections of that institution, rather than an attempt to classify the Tubinares. In that paper the skeleton of *Oceanodroma furcata* is fully described and figured, also the skeletons of *Fulmarus glacialis* and *F. rodgersii*, ten figures being devoted to the bones of the latter species.

A section is also devoted to the "Osteological points wherein *Oceanodroma furcata* and *Fulmarus rodgersii* differ," and this is followed by some notes on the osteology of *Puffinus tenuirostris* and other material. Finally, a very complete account is given of the skeleton of *Diomedea albatrus*, it being illustrated by twelve figures (nat. size), giving the skull (four views), the vomer (two views), the mandible (two figures), the hyoid arches, the sternum (two figures), and the shoulder-girdle.² Taken in connection with my examinations of additional material since that paper was published, and a study of the foregoing works of other authors, the present brief memoir aims simply to bring this subject up to date. I have never been able to get the skeletons of a great many species of procellarine birds, a number of which have been described by Forbes in his above cited work, and the student may readily consult these in the volume of his collected scientific Memoirs published by the Zoological Society of London (R. H. Porter). Either wholly or in part, Forbes examined skeletons of *Diomedea albatrus*, *Thalassogeron culminatus*, *Phaetria fuliginosa*, *Ossifraga gigantea*, *Fulmarus glacialis*, *F. glacialisoides*, *Dap-*

¹ Cope, E. D. Synopsis of the Families of the Vertebrata. The Amer. Nat. XXIII, Phil. Oct. 1889, p. 849 *et seq.*

² Shufeldt, R. W. Observations upon the Osteology of the Orders Tubinares and Steganopodes. Proc. U. S. Nat. Mus., Vol. XI, Washington, 1889, pp. 253-315.

tion capensis, *Oceanodroma leucorhoa*, *Oceanites oceanicus*, and *Pelagodroma marina*. The skeletons of a number of these have also been examined by me, and in addition thereto I have studied complete skeletons of *Puffinus borealis*, *P. major*, *P. griseus* (?), *P. creatopus*, *Oceanodroma furcata* and others. We also both examined a skeleton of *Puffinus obscurus*, and he also a skeleton of *Bulweria columbina*.

Considering the rarity in collections of the skeletons of tubinarine birds, the ground is pretty well covered by our united examinations, though it is highly desirable that many or all of the others be in time anatomically examined and compared.

II. SOME GENERAL NOTES ON THE OSTEOLOGY OF THE TUBINARES.

Bearing in mind what Forbes has recorded in his papers on the palate of the Tubinares (*Coll. Sci. Mem.* p. 416), I would say in addition thereto that I find in a skull of *Puffinus borealis* before me, that the inner ends of the maxillo-palatines abut against, on either side, the nearly vertical and lofty scroll of the corresponding palatine. The meeting is quite extensive and coössification appears almost to have taken place at the point of contact. The fenestration in them is hardly evident. We likewise find in the skull of *P. borealis* that the descending plates of the palatines are quite as prominent and well developed as the ascending ones just referred to, while the pterygoidal heads of these bones (palatines) in this shearwater are notably long, and closely applied to each other in the middle line, and to the sphenoidal rostrum. In it, too, the os uncinatum is well seen, being a distinct spine of bone, articulating, upon either side, with the infero-internal border of the lacrymal with its *free* apex pointing downwards and inwards towards the ascending plate of the palatine. In this shearwater the lacrymal is large and pneumatic. It articulates extensively, but does not ankylose with the corresponding frontal and nasal bones, and internally with the broad outer end of the pars plana. Its descending end is bifid and comes in contact with the zygoma, while superiorly its anterior apex is finely pointed, but posteriorly

is blunt and juts backwards and slightly outwards, being found just at the point where the deeply sculptured supra-orbital glandular depression terminates in front. Contrary to Forbes' statement that "well-developed basipterygoid facets are present in all

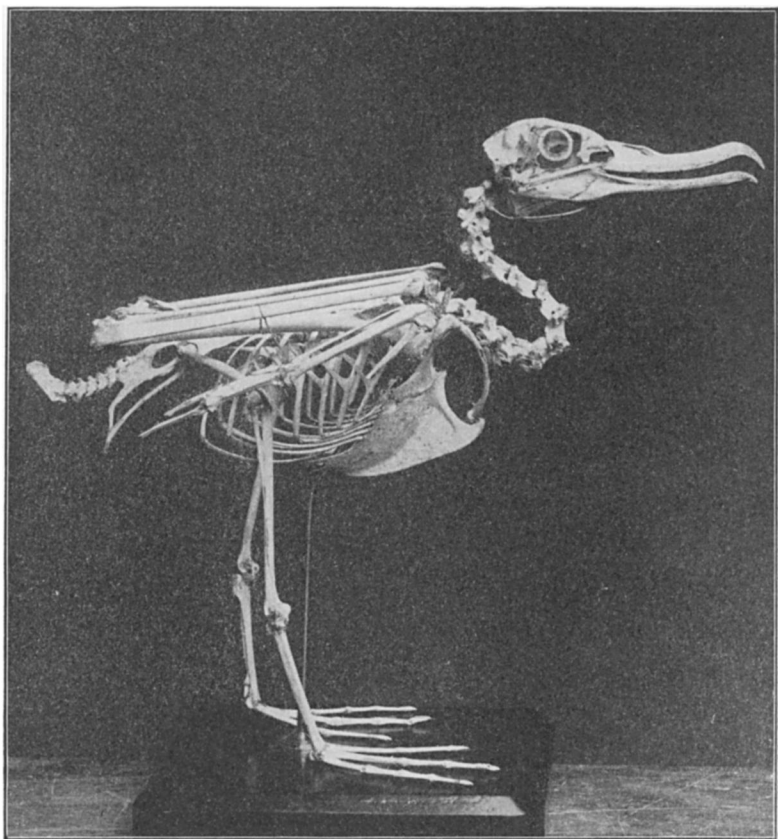


FIG. 1. Right lateral view of the skeleton of a Shearwater (*Puffinus borealis*). Coll. U. S. Nat. Museum, No. 17,772. (From a photograph by Prof. T. W. Smillie, and reduced.)

the forms, except the Diomedinæ, the Oceanitidæ, Procellaria, and Cymochorea," (p. 416), I find them but rudimentary in this specimen of *Puffinus borealis* (No. 17776. Smithsonian Collections), though they are well-developed and functional in a specimen of *Puffinus creatopus* (No. 18,773, Smithn. Coll.). In this last-

named species, too, the maxillo-palatines are well-anterior to the ascending plates of the palatine; moreover, its vomer is notched at its apex, and is not especially curved downward anteriorly. These are three well-marked differences in *Puffinus borealis* and *P. creatopus*, and go to prove, what I have always held, that we can never have too much material before as when comparing the skulls or any other part of the anatomy of birds.

So far as my observation goes I find that Forbes's description of the quadrate bone for the *Tubinares* agrees with what I found in other species of the group not examined or seen by him. But my material does not bear him out so well in his description of the foramen magnum of the *Tubinares*, and he says that that opening "is more or less reniform, with the major axis transverse, in the small species, whereas in the biggest it is oval, especially in *Ossi-fraga*, with the long axis vertical. The moderately sized species are here again intermediate in structure" (p. 417). Of the two shearwaters (*Puffinus*) before me, birds nearly of a size, and both above the "small-sized species" of the group, it is found to be oval in *Puffinus borealis*, with its major axis vertical, while in *Puffinus creatopus* the foramen magnum is subcircular with the major axis transverse.

The mandible of *Puffinus borealis* has the articular ends somewhat massive, truncated posteriorly, with very deep ramal sides for its hinder half, and very shallow ones anteriorly. Apically it is decurved, and there are lacking recurved angular processes and ramal vacuities. The articular ends are pneumatic, with the facets for the quadrate, of course, the reverse in form to those found on the last-named bone.

The distal elements of the greater cornua of the hyoidean apparatus are much flattened from above downwards, and, as in the Albatrosses, the parts anterior to the basibranchials are not performed in bone. The first basibranchial is subcircular in form, and anchyloses with a short urohyal or second basibranchial (*Puffinus*).

The sclerotic plates in an eye of *P. borealis* are small, and somewhat numerous; they are disposed as we usually find them among birds.

Axial Skeleton: — In the skeleton of *Puffinus borealis* at hand,

I find twenty-one free vertebræ between the skull and sacrum. Of these the thirteenth, fourteenth and fifteenth support a free pair of ribs; they being quite rudimentary upon the first two, but are long and slender on the fifteenth vertebra, and are without unciform appendages. The following *six* vertebræ have ribs that connect with the sternum by costal hæmapophysis. There is also a pair of sacral or pelvic ribs, but their hæmapophyses fail to reach the sternum, and their lower ends make extensive articulation with the last pair of true costal ribs, at some distance above the costal border of the sternum. The pelvis very much resembles the pelvis of Rodger's Fulmar figured by me in the Proceedings of the U. S. National Museum (cited above), and there are eight free caudal vertebræ plus a somewhat elongated pygo-style.

The costal border of the sternum is characteristically wide from side to side, and the pits between the six facettes, unmarked by pneumatic openings, are very shallow. The sternums of these shearwaters agree in their general characters with those of the fulmars.

In *P. borealis* the xiphoidal extremity is doubly notched upon either side of the sternal keel, and the form of the bone is there symmetrical. This is not the case with the xiphoidal extremity of the sternum of my specimen of *Puffinus creatopus*. In it, not only is the left side of the bone somewhat *longer* than the right, but instead of showing the two usual notches of the right, it has three, which appears to have been caused by a bifurcation of the inner xiphoidal process. These inner xiphoidal processes in *P. obscurus* are wonderfully slender.

The shoulder-girdle is much like that of *Daption capensis*, and in Figure 1 I present those parts in that species articulated *in situ* with the sternum. This figure originally illustrated a paper of mine which appeared in the Proceedings of the U. S. National Museum for 1887 (fig. 1, v. X. p. 379), where the skull is likewise described in connection with other observations upon the osteology of the Tubinares, and these should be read in connection with the present memoir.

Returning to the shearwaters, I may say that the arrangement of the bones of the shoulder-girdle in some of them is as we find

it in *Daption*, and this is the case with *Puffinus obscurus*. The sternum of the former, however, is non-pneumatic, a condition not found in *Puffinus*.

Forbes in his work presents a careful and somewhat lengthy description of the Pectoral arch in general for the *Tubinares*, and it agrees very closely with my own observations upon that bone. I have at present nothing to add to it.

In a specimen of *Puffinus borealis* I find the humerus to measure in length 135 millimetres. The bone is non-pneumatic, and is

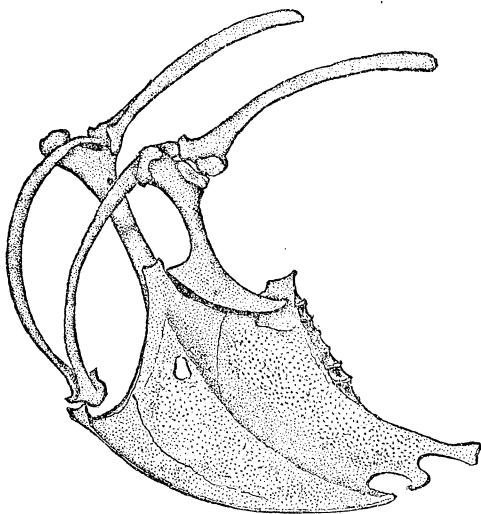


FIG. 1.—Anterior oblique view of the sternum of *Daption capensis*, with the shoulder girdle *in situ*. (Drawn by the author from a specimen in his own collection).

remarkable especially for the prominence of its jutting, papilliform ulnar crest, and conspicuous triangular radial crest. Its shaft is quite straight, and at its distal end, proximal, to the external condyle, we find a strongly developed epicondylar process. Attached to this by ligament is an ossicle of some considerable size, being 14 millimetres long, and of an L-form, with the short arm of the L bent to an obtuse angle. A rather deep, well-defined fossa exists immediately above the oblique tubercle, while the olecranon fossa on the opposite side of the bone is decidedly shallow. "In the Oceanitidae the humerus is conspicuously a stouter and shorter bone, with its shaft evidently curved instead

of being almost straight [as it is in *Puffinus*]. The epicondylar process projects much less forwards, and is continued down by an elevated ridge to the surface of the condyle itself." (Forbes, p. 422).

Both radius and ulna in *Puffinus* are comparatively very slender bones, the former, measuring 125 mm., is straight, and presents a well-marked tendinal groove at its disto-superior aspect, over the carpal enlargement. The ulna is likewise a very straight bone in the shearwaters, with the elevations for the quill-butts of the secondary remiges absent from the shaft. Its ends are but very slightly enlarged, as they are in some birds.

The skeleton of the hand has a length almost equaling the length of the radius. The terminal finger-points are long, slender, and pointed distally. Claws are absent. The proximal phalanx of index digit is very long and narrow; its blade not being fenestrated as in the Laridæ. Large and small shafts of the carpo-metacarpus are rather close together and markedly straight. Above its proximal end is a spindle-shaped, free ossicle of some considerable size. Possibly it occurs in the tendon of the tensor patagii longus close to its insertional extremity, but it exhibits no articular facette for the wrist, as does the os prominens of the Owls and others.

The small phalanx of the medius digit is notably free, and develops a tendinal tubercle upon its posterior border. Forbes describes the pectoral limb as it exists in the Oceanitidæ, in *Adamastor*, in *Majaqueus*, and in *Ossifraga* of the Procellariinæ, and compares the same as the skeleton of this limb is found in the Diomedeinæ (*loc. cit.* pp. 422, 423).

Puffinus borealis has a femur that in length hardly equals half that of the tibio-tarsus; it is somewhat antero-posteriorly arched, the convexity being along the anterior border. Its upper end is also antero-posteriorly flattened, with the trochanterian crest about absent, and the pit for the ligamentum teres much scooped out. A small free patella exists. In the tibio-tarsus the striking feature is the enormous development of its procnemial crest with a corresponding sub-suppression of the ectocnemial one. This is even still more marked in *Puffinus creatopus*, where upon the posterior aspect of the common prominence, a well-marked, transverse groove exists, apparently for the accommodation of the

lower margin of the patella. The remaining characters of the balance of the pelvic limb of *Puffinus* have already been correctly described by Forbes, and consequently it will not be necessary to reproduce his description in this place. He has also compared those characters with those found in various other representatives of this group of birds including *Diomedea*, *Pelecanoides*, the *Oceanitidæ*, and the Petrels. (*loc. cit.*, pp. 424, 425.)

In examining the skeleton in the *Oceanitidæ* I found among other things that they lack in the skull the basipterygoid processes, and that in them the uncinatæ bones, found in the skulls of other *Tubinares* are also absent. The posterior margin of the xiphoidal extremity of the sternum, is usually quite entire; and they have but twenty-one cervico-dorsal vertebræ. These birds also possess, in contradistinction to the *Procellariidæ*, short and stout humeri, a character which is also seen in the long bones of the fore-arm.

III. ON THE TAXONOMY AND AFFINITIES OF THE TUBINARES.

There is a combination of a few marked osteological characters which will serve to distinguish any member of the present suborder from any other existing avian group. The *Tubinares* all have their skulls characterized by the presence of conspicuous supra-orbital glandular depressions, which are large and generally deeply sculpt.

They are likewise all holorhinal, as well as schizognathous birds, wherein the vomer is usually of considerable size, being more or less broad, pointed anteriorly, and often depressed and arched antero-posteriorly. Combined with these characters we find that in them the hallux of pes to be either absent or else rudimentary in that it is reduced to a single joint. Not more than twenty-three cervico-dorsal vertebræ, nor less than twenty-one are seen to exist. The sternum is short and broad, with its posterior border either entire, or regularly 4-notched, or of an asymmetrical pattern, or even jagged. The patella, when present, is free and small, articulating high up on the posterior aspect of the much-produced procnemial crest of the tibio-tarsus. The sternal extremity of a coracoid is of remarkable width, being nearly as wide there as the bone is long from summit to midpoint

of base. The superior mandible of the skull is conspicuously decurved apically, and very sharp-pointed; symphysis of mandible also more or less decurved, and the articular ends of this bone, truncated posteriorly.

When the skeleton of any bird has associated in it all the osteological characters here enumerated, they are sufficient to indicate that the species belongs to the suborder Tubinares. These characters are thoroughly diagnostic, and typical tubinarine forms possess them in the avifauna in any part of the world.

I am of the opinion that the natural classification of the Tubinares is as follows:—

SUBORDER.	FAMILIES.	SUBFAMILIES.
TUBINARES.	1. Procellariidæ.	{ 1. Procellariinæ.
		{ 2. Oceanitinæ.
	2. Puffinidæ.	{ 3. Puffininæ.
		{ 4. Fulmarinæ.
	3. Pelecanoididæ.	
	4. Diomedeidæ.	

This arrangement does not include the extinct forms of this suborder, but nevertheless the characters presented on the part of these have been taken into consideration in connection with taxonomical affinities.

When Mr. Forbes came to sum up his conclusions in regard to this group of birds, at the close of his extensive paper, cited above, he said that L'Herminier, A. Milne-Edwards, and Huxley have all, in describing various points in the osteology of the Tubinares, pointed out similarities of various kinds between their osseous structure and that of various forms of Steganopodes, though they still kept them close to the Laridæ. Eyton, on the other hand, places the various petrels he describes in the family 'Pelecanidæ,' and gulls forming a separate family by themselves."

"But no one will be prepared, I think, to dispute that the Steganopodes are allied to the Herodiones, including under that name the Storks and Herons, with *Scopus* only."

"Thus, on osteological grounds alone, there is sufficient ground for placing the Tubinares in the vicinity of the Steganopodes and Herodiones. And, in fact, neglecting the desmognathous structure of the palate—the taxonomic value of which, *per se*, is becoming

more and more dubious as our knowledge of the structure of birds increases — there is little in the character assigned to the groups Pelargomorphæ and Dysporomorphæ by Professor Huxley that is not applicable to the general Petrel type.” (*loc. cit.* p. 434.)

In this connection it is interesting to observe that the Tubinares possess, in common with the Cathartidæ, the Steganopodes, and the Ciconiidæ, a deep-keeled, broad and well-developed sternum; external osseous nares holorrhinal; articular ends of mandible posteriorly truncated; an evident tendency of the palatine bones to unite with each other for their posterior moieties; powerfully developed clavicles, which are strongly curved, — and these osteological characters co-exist with other similarities to be found in other parts of the morphological organizations of the respective groups mentioned.

Structurally, the Cathartidæ are of great interest, and the anatomy of those peculiar terrestrial scavengers must be still better known to us than it is, before we can hope to trace their probable ancestry.

Remotely akin to the Steganopodes, the Falconidæ, or more generally, the Accipitres, also are linked with these more lowly avian groups, — as are also the Arleidæ, through Scopus.

During the ages past, it is quite evident that hosts of intermediate forms linking these families and groups have perished and become extinct. This, taken in connection with the very marked specialization of the remaining genera, goes far towards proving the great antiquity of the entire group, and how vast that extinction of the less specialized forms must have been.

My impression is that perhaps the Tubinares on the one hand see their nearest relatives in the Steganopodes, in fact there can now hardly be any doubt upon this point, — while upon the other hand I am inclined to think that the penguins (*Impennes*) might be with truth placed next below them, as Fürbringer has done. But such questions as these I will take up more thoroughly later on, when I come, in another connection, to draw up my scheme of classification for the Class *Aves*, and after I have paid further attention to the osteology of other existing groups.

NOTE: — In closing this Memoir I would say that since it was written there has appeared in the *American Naturalist* my con-

tribution entitled "An Arrangement of the Families and the Higher Groups of Birds (Vol. XXXVIII, Nos. 455-456 Nov-Dec. 1904, pp. 833-857), and, in so far as the taxonomy of the Tubinares is concerned, it sustains what is set forth above; in other words my opinion in the matter remains the same as it was six years ago.